APPENDIX A

FACILITY DESCRIPTION

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LIST OF ABBREVIATIONS/ACRONYMS

20.4.1 NMAC	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
µg/L	microgram(s) per liter
AASHTO	American Association of State Highway and Transportation Officials
amsl	above mean sea level
cm/yr	centimeters per year
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ft	feet/foot
GPP	Groundwater Protection Program
HE	high explosives
IC	ion chromatography
LANL	Los Alamos National Laboratory
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
mg/L	milligrams per liter
m/s	meters per second
m/yr	meter(s) per year
NMED	New Mexico Environment Department
pCi/L	picocuries per liter
ppb	parts per billion
R&D	research and development
RLWTF	Radioactive Liquid Waste Treatment Facility
RRES	Risk Reduction and Environmental Stewardship Division
TA	technical area

APPENDIX A

FACILITY DESCRIPTION

The information provided in this appendix is submitted in accordance with the applicable requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20.4.1 NMAC), revised June 14, 2000 [6-14-00]. The following subject areas are addressed in this appendix or are referenced to technical area (TA)-specific permit applications, permit modification requests, or permit renewal applications:

- A general description of the Los Alamos National Laboratory (LANL) facility [20.4.1 NMAC § 270.14(b)(1)];
- Traffic patterns, volume, and control [20.4.1 NMAC § 270.14(b)(10)];
- Facility location information for compliance with the seismic standard and floodplain requirements [20.4.1 NMAC §§ 270.14(b)(11) and 270.14(b)(19)(ii), and 20.4.1 NMAC § 264.18(a) and (b)];
- Topographic map requirements [20.4.1 NMAC § 270.14(b)(19)];
- Groundwater [20.4.1 NMAC § 270.14(c) and 20.4.1 NMAC § 264.90(a)].

A.1 GENERAL DESCRIPTION [20.4.1 NMAC § 270.14(b)(1)]

LANL is located in Los Alamos County, an incorporated county, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. The regional location of LANL is shown on Figure A-1. LANL is divided into TAs, as shown on Figure A-2. LANL, which occupies an area of 40 square miles, and the associated residential and commercial areas of Los Alamos County, which occupy an area of approximately 109 square miles, are situated on the Pajarito Plateau. The plateau consists of a series of finger-like mesas separated by deep east-west trending canyons. Ephemeral, interrupted, or intermittent streams lie at the bottoms of all the canyons. The mesa tops range in elevation from approximately 7,800 feet (ft) above mean sea level (amsl) at the flank of the Jemez Mountains, located to the west of Los Alamos, to about 6,200 ft amsl at their eastern extent, where they terminate above the Rio Grande.

LANL's central mission is the reduction of global nuclear danger supported by research that also contributes to conventional defense, civilian, and industrial needs. This includes programs in nuclear, medium energy, and space physics; hydrodynamics; conventional explosives; chemistry; metallurgy; radiochemistry; space nuclear systems; controlled thermonuclear fusion; laser research;

environmental technology; geothermal, solar, and fossil energy research; nuclear safeguards; biomedicine; health and biotechnology; and industrial partnerships. LANL is owned by the U.S. Department of Energy (DOE) and is operated jointly by the DOE National Nuclear Security Administration and the University of California. The facility mailing address is P.O. Box 1663, Los Alamos, New Mexico, 87545.

LANL is an existing treatment and storage facility. This General Part B Permit Renewal Application and other TA-specific permit applications, permit modification requests, or permit renewal applications are submitted for treatment and storage units that are current or proposed “active” operating units. LANL does not seek an operating permit for any disposal units.

Hazardous waste is generated at LANL primarily from research and development (R&D) activities, general facility operations, environmental restoration (ER) activities, and decontamination and decommissioning (D&D) projects. Mixed low-level waste is generated mainly from R&D activities, processing and recovery operations, general facility operations, D&D projects, and ER activities. Mixed transuranic waste is generated primarily from R&D activities, processing and recovery operations, and D&D projects. High explosives (HE)-contaminated waste is generated mainly from R&D activities, ER activities, wastewater treatment processes, and building maintenance and modification activities. Brief descriptions of specific hazardous and mixed waste management units at LANL are presented in Attachment A of TA-specific permit applications, permit modification requests, or permit renewal applications. Waste generated from R&D activities, processing and recovery operations, and ER activities may be received from off-site facilities, as described in Supplement 1 of this General Part B Permit Renewal Application.

A.2 TRAFFIC PATTERNS [20.4.1 NMAC § 270.14(b)(10)]

The traffic pattern information presented below is general in nature. More detailed information is addressed in TA-specific permit applications, permit modification requests, or permit renewal applications.

A.2.1 General

The rugged topography of alternating mesas and canyons present at LANL limits traffic circulation to only a few major arterial roads. Approximately 85 miles of paved roads are present within LANL (Pan Am World Services Inc., 1986). The major roads are shown on Map 1 in the most recent version of the “Los Alamos National Laboratory General Part A Permit Application,” hereinafter referred to as the LANL General Part A. There are approximately 19 miles of highway, 22 miles of TA access roads, and 44 miles of roads in LANL's TAs.

The main access route to LANL is State Road 502; the majority of traffic to LANL approaches from the east on State Road 502 and East Jemez Road. Alternate access routes are available from the south and west on State Roads 4 and 501 (West Jemez Road).

The pattern of east-west trending canyons at LANL prohibits north-south automobile travel in nearly all portions of LANL, with the exception of Diamond Drive and part of West Jemez Road. Los Alamos Canyon is spanned at Diamond Drive by an 820-ft-long steel-arch bridge that was completed in 1951 and improved in 1993. This bridge provides the main access between LANL facilities located on either side of Los Alamos Canyon.

Approximately 10,000 people are currently employed at LANL (including full-time, part-time, and casual LANL personnel and subcontractors). Roughly 4,000 people commute to LANL daily from communities outside Los Alamos County.

A.2.2 Waste Collection Areas

Hazardous and mixed waste is generated at TAs throughout LANL. Small quantities of waste are generally accumulated in containers at less-than-90-day storage areas or satellite accumulation areas and then packed in containers, such as drums, boxes, or crates, for transport to storage or treatment areas, as necessary. Bulk liquid waste is contained primarily in drums or tanks. Because hazardous and mixed waste may be generated throughout LANL, waste transport may occur on nearly all roads within LANL. Off-site wastes may be received at LANL on a limited basis.

A.2.3 Routes of Travel

Information addressing unit-specific travel routes is presented in Attachment A of TA-specific permit applications, permit modification requests, or permit renewal applications.

A.2.4 Traffic Volumes

According to a traffic study conducted in early 2003, the peak traffic periods are between 6:00 and 8:00 a.m. and 4:00 and 6:00 p.m. Monday through Thursday, and between 6:00 and 8:00 a.m. and 3:00 and 5:00 p.m. Friday (Digital Traffic Systems, 2003). The 2003 traffic study was conducted at 10 locations throughout Los Alamos County. The data collection locations are shown on a figure in

Supplement 2 of this document. A data summary and the data from the cited study are also presented in Supplement 2. Based on the study, the daily average number of vehicles is greatest on Monday through Friday near the intersection of Diamond Drive and Trinity Drive (Site 2 in the study), with 25,820 vehicles. The smallest daily average number of vehicles on Monday through Friday is 1,539 near the intersection of West Jemez Road and State Road 4.

Additional traffic volume information is provided in Attachment A of TA-specific permit applications, permit modification requests, or permit renewal applications.

A.2.5 Traffic Control Signals

Site-wide traffic flow at LANL is controlled by traffic lights, stop signs, and yield signs. Traffic lights are in place at all major intersections. Traffic signs are used at "T" intersections throughout LANL. Access to high security TAs is controlled by security guards or special access gates. Only personnel having appropriate security clearance and identification or escorted visitors are allowed access to the high security TAs. Vehicles and personnel entering these TAs are subject to periodic search by security personnel.

Unit-specific information addressing traffic control signals is presented in Attachment A of TA-specific permit applications, permit modification requests, or permit renewal applications.

A.2.6 Road Load-Bearing Capacity

Roads at LANL carrying the greatest traffic volumes include Diamond Drive, Pajarito Road, and East and West Jemez Roads. These roads are typically constructed with an 8-inch-thick base overlain with a 5-inch-thick asphaltic-concrete surface, and were designed and built in conformance with American Association of State Highway and Transportation Officials (AASHTO) specification HS-20 (AASHTO, 1996). This specification is intended to accommodate truck loading capacities of 32,000 pounds per axle. Roads within TAs are generally two-lane roads with asphaltic-concrete surfaces. These roads are typically constructed with a 6-inch-thick base overlain with a 3-inch-thick asphaltic-concrete surface. These roads were also designed and constructed to meet AASHTO specification HS-20.

A.3 LOCATION INFORMATION

A.3.1 Seismic Standard [20.4.1 NMAC § 270.14(b)(11)]

LANL is an "existing" facility that met the requirements for interim status under Section 74-4-9 of the New Mexico Hazardous Waste Act and Section 3005(e) of the Resource Conservation and Recovery Act. The U.S. Environmental Protection Agency (EPA) specifically exempted "existing" facilities operating under interim status from the requirement under 20.4.1 NMAC § 270.14(b)(11) to submit a Part B permit application that demonstrates compliance with the seismic standards under 20.4.1 NMAC § 264.18(a) [see *46 FR 2802* and *46 FR 2813* (January 12, 1981)].

A.3.2 Floodplain Standard [20.4.1 NMAC §§ 270.14(b)(11)(iii through v) and 270.14(b)(19)(ii); 20.4.1 NMAC § 264.18(b)]

As required in "Module VIII: Special Conditions Pursuant to the 1984 Hazardous and Solid Waste Amendments to RCRA for Los Alamos National Laboratory, EPA I.D. NM0890010515" (EPA, 1994), LANL mapped all 100-year floodplain boundaries within the LANL complex. A report was published documenting the floodplain mapping procedures (McLin, 1992). These maps were revised after the Cerro Grande Fire, and a new report was generated (McLin et al., 2001). The new maps and new report were provided to the New Mexico Environment Department (NMED) as Appendices B and C in the November 2001 Response to a Request for Supplemental Information (LANL, 2001). As shown on the new maps, no hazardous waste management units to be permitted are located within the 100-year floodplain at LANL. The new report is included as Supplement 3 in this document.

A.4 TOPOGRAPHIC MAPS [20.4.1 NMAC § 270.14(b)(19)]

Due to the size of LANL, several maps and figures are provided or referenced to meet the requirements of 20.4.1 NMAC § 270.14(b)(19) [6-14-00]. All maps clearly show the map scale, the date of preparation, and a north arrow. The maps and figures used to fulfill these regulatory requirements include the following:

- LANL-wide 100-year floodplain maps were provided as Appendix C of the "Response to Request for Supplemental Information: Technical Adequacy Review, RCRA Permit Application: General Part A, April 1998, Revision 0.0; General Part B, October 1998, Revision 1.0; Los Alamos National Laboratory, EPA ID No. NM0890010515" (LANL, 2001).
- A map showing surface waters, including intermittent streams, and flow direction is included in the LANL General Part A.
- Surrounding land uses are shown on Map 1 in the LANL General Part A.
- Wind roses for LANL are shown on Figures A-3 and A-4 of this appendix.

- Access control features (e.g., fences, gates) are shown on a figure(s) in TA-specific permit applications, permit modification requests, or permit renewal applications.
- Buildings and structures are shown on maps in the LANL General Part A and on figures in TA-specific permit applications, permit modification requests, or permit renewal applications.
- The locations of the hazardous and/or mixed waste management units at LANL are shown on maps in the LANL General Part A and on figures in TA-specific permit applications, permit modification requests, or permit renewal applications.
- A map showing National Pollutant Discharge Elimination System discharge structure locations is included in the LANL General Part A.
- Storm, sanitary, and process sewer systems at LANL are shown on Map A-1 of this appendix.
- A map showing the boundaries of LANL is provided as Map A-2 in this appendix.
- Drainage control features (e.g., run-on/runoff) are shown on a figure(s) in TA-specific permit applications, permit modification requests, or permit renewal applications.
- Fire stations serving LANL and the County of Los Alamos are shown on Figure E-2 of Appendix E.
- An equipment cleanup area for LANL is located at TA-50-1. The location of TA-50-1 is shown on Figure 50-1 in the LANL General Part A.

Contour lines on all topographic maps are in intervals sufficient to detail natural drainage at LANL and in the vicinity of the waste management units. As provided in 20.4.1 NMAC § 270.14(b)(19) [6-14-00], LANL has submitted the maps at these scales and contour intervals due to the size of the waste management units, the extent of the LANL facility, and the topographic relief in the area.

A.5 GROUNDWATER [20.4.1 NMAC § 270.14(c) and 20.4.1 NMAC § 264.90(a)]

The following information is provided to meet the requirements of 20.4.1 NMAC § 270.14(c) [6-14-00] for regulated units subject to corrective action.

In the Los Alamos area, groundwater occurs in three modes: (1) water in shallow alluvium and underlying tuff in some of the larger canyons, (2) intermediate perched zone groundwater (a perched groundwater body above a less permeable layer and separated from the underlying aquifer by an unsaturated zone), and (3) the regional aquifer of the Los Alamos area.

A.5.1 Alluvial Groundwater Occurrence

Infiltration of surface water flow (caused by effluent discharges, spring discharge, or stormwater runoff) maintains shallow groundwater in the alluvium of some canyons. Alluvial groundwater is unconfined and is perched on underlying Bandelier Tuff, Cerros del Rio basalts, or Puye Formation.

In wet canyon bottoms, infiltration of surface water maintains shallow groundwater in the alluvium. Wet canyons generally have large surface water flow, head in the Jemez Mountains, or receive effluent discharges. Groundwater levels are typically highest in the late spring due to snowmelt runoff and in mid-to-late summer due to thunderstorms. Groundwater levels and extent of saturation decrease during the winter and early summer when runoff is at a minimum. Dry canyons have little surface water flow. In these canyons, groundwater may occur seasonally in the alluvium. Dry canyons are generally those that head in the eastern portion of the Pajarito Plateau.

Alluvium that is as much as 100 ft thick has been deposited in the canyons of the Pajarito Plateau by intermittent and ephemeral stream flows. Alluvium in canyons that head in the Jemez Mountains is generally composed of sands, gravels, pebbles, cobbles, and boulders derived from the Tschicoma Formation and Bandelier Tuff on the flank of the mountains. Alluvium in canyons that head on the Pajarito Plateau is relatively fine-grained and consists of clays, silts, sands, and gravels derived from the Bandelier Tuff. In Mortandad Canyon east of Test Well 8, the alluvium has two distinct lithologic zones: the upper zone is a coarse-grained pebbly sand; the lower zone is a brown sandy silty clay, which rests unconformably on the Bandelier Tuff (Baltz et al., 1963, p. 31).

Ephemeral runoff in some canyons infiltrates the alluvium until downward movement is impeded by the less permeable underlying strata. The impeded downward movement results in a buildup of shallow alluvial groundwater. In some cases, relatively thin zones of shallow groundwater can also be contained in the weathered tuff or some other geologic unit immediately underlying the alluvium. The horizontal and vertical extent of the alluvial groundwater is limited by depletion via evapotranspiration and movement into the underlying rocks (Purtymun et al., 1977). The limited saturated thickness and extent of the alluvial groundwater within the Laboratory boundaries make it inadequate as a significant source of potable and industrial water supply to LANL .

A.5.1.1 Alluvial Groundwater Flux

Lateral flow of the alluvial groundwaters is down canyon and in an easterly direction. Purtymun (1974) used observed travel times through the alluvial groundwater of Mortandad Canyon of a pulse of tritium released from TA-50 to infer the large-scale permeability of the alluvium. Based on this study, the velocity of alluvial groundwater flow ranges from about 60 ft per day in the upper reach to about 7 ft per day in the lower reach of the canyon (Purtymun, 1974). Purtymun (1974) determined field-scale hydraulic conductivity values to several zones of different texture within the alluvium, which were identified during a study by Baltz et al. (1963). Chloride and tritium tracer measurements were used to estimate the hydraulic conductivities. The upper zone has a hydraulic conductivity of 1.6×10^{-3} meters per second (m/s) between MCO-5 and MCO-6. The lower zone has a hydraulic conductivity of 5.8×10^{-4} m/s between MCO-6 and MCO-7.5, and 8.8×10^{-5} m/s between MCO-7.5 and MCO-8.

A.5.1.2 Alluvial Groundwater Quality

Water quality of the alluvial groundwater reflects the composition of storm runoff, snowmelt, and effluent discharges, where present. In canyons affected by effluents, the alluvial groundwater and sediments contain the majority of adsorbing contaminants (such as plutonium). Mobile solutes (such as tritium, HE compounds, and anions) migrate with moving groundwater, and are present in recharge. Contaminated alluvial groundwater occurs in Acid/Pueblo, DP/Los Alamos, and Mortandad canyons, and in Cañon de Valle, and potentially in other canyons where full investigations have not yet been conducted. In Acid/Pueblo, DP/Los Alamos, and Mortandad canyons, the contamination resulted from discharges from radioactive liquid waste treatment facilities (and untreated discharges in Acid/Pueblo Canyon). The groundwater and sediments are contaminated with residual radionuclides, including cesium-137, strontium-90, plutonium isotopes, and americium-241. In Mortandad Canyon, samples collected from alluvial shallow groundwater monitoring wells (Wells MCO-3 through MCO-6) in Mortandad Canyon in December 1999 contained perchlorate concentrations ranging from 80 to 220 parts per billion (ppb). Other components of the discharges included fluoride and nitrate. Cañon de Valle contains residues from past discharges of HE wastewater.

A permeable reactive barrier was installed in Mortandad Canyon in 2002 to remove from alluvial aquifer water radionuclide and chemical contaminants resulting from legacy discharges to the canyon. Alluvial water that encounters the barrier is scrubbed of radionuclides (such as strontium-90, americium-241, and plutonium and uranium isotopes) as well as chemicals (such as perchlorate, nitrate, and heavy metals). To assess the effectiveness of the barrier, samples of water and materials inside the barrier's treatment box and water upstream and downstream of the barrier will be collected for analyses.

A.5.2 Intermediate Perched Groundwater Occurrence

The areas where intermediate perched zone groundwater has been encountered in wells are shown in Table A-1. Intermediate perched zones occur beneath major canyons, particularly in wet canyons that receive effluent discharges, have large surface water flow, or head in the Jemez

Mountains. These intermediate perched zones occur in the Guaje Pumice Bed at the base of the Bandelier Tuff, the underlying Cerros del Rio basalts, and the Puye Formation. The location of intermediate perched zones is determined by presence of sufficient recharge, permeability variations of the rocks (reflecting lithologic variations), and geologic structure. Intermediate perched zones may be confined or unconfined. Intermediate perched zones beneath canyons do not generally extend laterally beneath the mesas.

Within drier mesas (generally in the eastern portion of the Laboratory), water can occur in the Bandelier Tuff under unsaturated conditions. Relatively little water (~1 millimeter/year) moves downward beneath the mesa tops under natural conditions due to low rainfall, high evaporation, and efficient water use by vegetation. Atmospheric evaporation extends within mesas, drying out the mesa interior and decreasing downward flow. Moisture content of the tuff varies with recharge rate and with texture of the lithologic units (Nylander et al., 2001). Generally, at depths of below 10 ft, the moisture content of the tuff varies from about 4 to 6% on the mesas. In the eastern portion of the Laboratory (e.g., in Los Alamos Canyon), perching layers are found within the interbedded Cerros del Rio Basalt and the Puye Formation sediments, where they underlie the more permeable Guaje Pumice Bed (Table A-1).

For wet mesas (generally along the western portion of the Laboratory), water occurs in the Bandelier Tuff primarily under unsaturated conditions. At the mesa top Well R-25 at TA-16, relatively low moisture contents in the Tshirege Member of the Bandelier Tuff range from 2% to 5%. The moisture content increases through the lower units of this member to about 21% in the top of the Cerro Toledo interval. Moisture content in the upper portion of the Otowi Member is about 7%, and increases at depth to approximately 20%. Groundwater also occurs as transient zones of saturation and in perennial saturated ribbons of limited spatial extent, which feed springs on the mesa sides. The saturated zones are localized by fractures and by permeability changes related to lithologic variations within the Bandelier Tuff. Higher rainfall and increased welding and jointing of the tuff lead to greater recharge rates for wet mesas than observed in drier mesas. In addition to spring discharge at mesa sides, saturated and unsaturated flow through mesas result in recharge to the underlying intermediate perched zones or the regional aquifer. In the western portion of the Laboratory, groundwater occurs as a thick (300-ft) intermediate perched zone within the lower Bandelier Tuff and the Puye Formation, approximately 700 ft below the mesa top.

Mesa top recharge under disturbed surface conditions is higher than under natural conditions. Increased recharge occurs when the soil is compacted, when vegetation is disturbed, or when more water is added to the hydrologic system by features such as pavement or effluent discharge. Fractures within mesas could provide preferential pathways for contaminants, especially in regions of high infiltration and in rocks of low matrix permeability. Fracture flow is less likely to occur when the rock matrix is porous and permeable, because water is drawn out of the fractures.

Characterization over the past decade has significantly improved the understanding of the hydrogeologic setting at LANL, including intermediate perched zone groundwater. The vertical and lateral extent of the perched zones, the nature and extent of the perching units, and the potential for migration of perched groundwater to the regional aquifer continue to be investigated. Drilling of alluvial wells and regional aquifer wells that intersect intermediate perched groundwater has provided sufficient information thus far that indicates that neither alluvial nor perched saturated water exist to any significant vertical extent. From the data and information generated thus far, LANL believes that upon completion of the Hydrogeologic Workplan, anticipated in calendar year 2004, sufficient information will have been generated through well installation and modeling to create a technically-based conceptual model of the alluvial and perched water zones. Such information will help fulfill the objectives and purpose of site-wide characterization under the Hydrogeologic Workplan.

Upon completion of the Hydrogeologic Workplan, it is anticipated that additional hydrogeologic characterization will be performed as part of Investigation Work Plans for canyons and aggregate areas. Information obtained during these investigations will be used to continue improving the conceptual model of the alluvial and perched water zones.

A.5.2.1 Intermediate Perched Groundwater Flux

Lateral movement of intermediate perched groundwater may occur if the dip of the perching horizon and the canyon orientation do not coincide. Most recharge for west side perched intermediate groundwater originates as underflow of groundwater from the Jemez Mountains, with some contribution from recharge through mesas and canyon bottoms. Discharge from the intermediate perched zones occurs at springs or results in recharge to the underlying regional aquifer. Studies have shown that the intermediate perched zone groundwater in Pueblo Canyon is hydrologically connected to the stream in Pueblo Canyon (Abrahams and Purtymun, 1966). This perched zone water discharges at the base of the basalt at Basalt Spring, located on San Ildefonso Pueblo land east of LANL in lower Los Alamos Canyon. It has been estimated that the rate of movement of the perched groundwater in this vicinity is about 60 ft per day, or about 6 months from recharge to discharge (Purtymun, 1975).

The direction and flux of water through the unsaturated zone have been examined in two studies. Rogers and Gallaher (1995) tabulated Bandelier Tuff core hydraulic properties from several boreholes at LANL to estimate recharge rates beneath the Pajarito Plateau. Rogers et al. (1996) used hydraulic properties from seven boreholes that had sufficient data to evaluate movement of water in the vadose zone. The seven boreholes were from mesa top and canyon bottom locations, which represent two of the distinct hydrologic regimes on the Pajarito Plateau. Most head gradients determined for the boreholes were approximately unity, thus implying that flow is nearly steady state. One exception was found for boreholes at TA-54, Area G, where gradient reversals at depths of about 100 ft suggest that evaporative drying may be occurring.

Infiltration rates for liquid water at the seven locations were approximated by Rogers et al. (1996), who used vertical head gradients and unsaturated hydraulic conductivity estimates in their calculations. As such, the apparent fluxes beneath mesa top locations range from approximately 0.06 centimeters per year (cm/yr) beneath Area G to 245 cm/yr directly beneath the TA-53 surface impoundments when they were operational. It is believed that high precipitation or surface disturbances (e.g., man-made ponds) lead to higher fluxes beneath some mesas. Beneath Cañada del Buey and Potrillo Canyon, two typically dry canyons, the apparent canyon-bottom infiltration rates range from 0.4 to 8.3 cm/yr. Beneath Mortandad Canyon, the canyon-bottom infiltration rates range from 1 to 10 cm/yr. More recent data from wet canyons have been interpreted to provide more comprehensive estimates. For Well R-15 in Mortandad Canyon, moisture profile measurements yield infiltration rate estimates on the order of 50 cm/yr. In Los Alamos Canyon, similar estimation techniques in canyon well LADP-3 were estimated to be consistent with infiltration rates of about 10 to 60 cm/yr. Such values are large enough that contaminants are predicted to travel through at least 100 meters of Bandelier Tuff during the time of Laboratory operations. This result is consistent with the observations of relatively deep penetration of contaminants such as perchlorate ion in R-15.

A.5.2.2 Intermediate Perched Groundwater Quality

Water quality within intermediate perched zones reflects that of the recharge water, including effluent discharges and native groundwater. Flow within intermediate perched zones could transport contaminants away from their surface source. Measurements of tritium in intermediate perched zone groundwater indicate that recharge to those depths has occurred during the last several decades. Observations made at four locations in Pueblo and Los Alamos canyons show that levels of tritium in the perched zone are high enough to be attributed to recharge of surface water contaminated by effluent or other releases from LANL operations. In a test well in Pueblo Canyon (TW-2A), tritium has been observed at concentrations between 2,000 and 3,000 picocuries per liter (pCi/L). Beginning in 1991, low-detection-limit tritium measurements have shown tritium levels of about 150 pCi/L in samples from a test well located in lower Pueblo Canyon near its confluence with Los Alamos Canyon (TW-1A), and in Basalt Spring, which is located in Los Alamos Canyon just downstream from its confluence with Pueblo Canyon. Measurements at these three locations are consistent with LANL's previous understanding that the intermediate perched zone groundwater in Pueblo Canyon has been affected by effluents discharged into the canyon. In the middle reach of Los Alamos Canyon, about one mile down gradient of TA-2, tritium was detected in the intermediate perched zone at well LADP-3 (Broxton and Eller, 1995). Perched groundwater was encountered at a depth of about 320 to 330 ft at this well, and water samples contained about 6,000 pCi/L of tritium.

In June 2001, characterization well MCOBT-4.4 was installed at the confluence of Mortandad and Ten Site canyons. Mortandad Canyon received effluent discharged from LANL's former wastewater treatment plant at TA-35 from 1951 to 1963 and from LANL's Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50 from 1963 to present. Tritium, fluoride, nitrate plus nitrate (as N), and perchlorate were detected in the perched groundwater samples collected from MCOBT-4.4. The nitrate and perchlorate concentrations exceeded the EPA primary standard for nitrate (10 milligrams per liter [mg/L]) and the draft provisional risk-based level for perchlorate (1 microgram per liter [µg/L]). Additional characterization sampling is being conducted at this well to evaluate contaminant concentrations in the perched zone (Broxton et al., 2002a). Results to date show that perchlorate concentrations range from 140 to 180 µg/L (ppb) at depths of 492 to 524 ft (Longmire, 2003).

A.5.3 Regional Aquifer Groundwater Occurrence

The regional aquifer of the Los Alamos area is the only aquifer known to be capable of providing the Los Alamos County community and Laboratory water supply (Purtymun, 1984). The surface of the regional aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Formation beneath the central and western parts of the Pajarito Plateau. The depth to the regional aquifer below the mesa tops (and adjacent canyons) ranges from about 600 ft at the eastern margin of the plateau (or near the surface at the Rio Grande) to about 1,200 ft along the western margin (or 900 ft below the deepest canyons). According to Purtymun (1984), the regional aquifer exhibits artesian conditions in the eastern part along the Rio Grande. Throughout the plateau, continuously recorded water level measurements collected in test wells since the Fall of 1992 indicate that the regional aquifer responds to barometric and earth tide effects in a manner typical of confined aquifers.

Twelve deep water-supply wells in three well fields currently produce water for LANL and the communities of Los Alamos and White Rock. The well fields include the off-site Guaje well field and the on-site Pajarito and Otowi well fields. The Guaje well field is located northeast of LANL and contains five production wells. The five production wells in the Pajarito well field are located in Sandia and Pajarito canyons and on mesa tops between these canyons. The Otowi well field is located in Los Alamos and Pueblo canyons, and consists of two production wells. Production of potable municipal water supplies from these three well fields from 1998 through 2001 ranged from approximately 1.32 billion gallons in 1999 to 1.51 billion gallons in 2000 (Koch and Rogers, 2003). Yields from individual production wells ranged from about 375 to 1,479 gallons per minute from 1998 through 2001 (Koch and Rogers, 2003). The long-term trends in water levels reflect a plateau-wide decline in regional aquifer water levels in response to municipal water production. The average annual decline is gradual and has ranged from 0.7 to 2 ft per year for production wells (Koch and Rogers, 2003).

A.5.3.1 Regional Aquifer Groundwater Flux

The Rio Grande is the main discharge area for the regional aquifer. The largest component of recharge occurs as underflow of groundwater from the Sierra de los Valles, to the west of the Pajarito Plateau. Recharge also occurs by leakage from wet mesas, from alluvial groundwater in canyon bottoms on the Pajarito Plateau, and from intermediate perched groundwater. Local recharge on the Pajarito Plateau is important because it provides potential pathways for contaminants that originate from effluent discharges (Nylander et al., 2001).

Recharge due to infiltration and percolation of alluvial groundwater can be a source of recharge to underlying intermediate perched zones and to the regional aquifer, usually by unsaturated flow. Recharge from alluvial groundwater by unsaturated flow accounts for important volumes of recharge and relatively rapid rates of groundwater flow (reaching the regional aquifer in decades or less). In some cases, recharge might occur by saturated flow. Faults, fractures, joints, surge beds, and higher permeability geologic units that underlie saturated alluvium (such as the Guaje Pumice Bed, Cerro Toledo Interval, Cerros del Rio basalts, and Puye Formation) could provide pathways for downward movement of water and contaminants. Moisture content of the Bandelier Tuff below wet canyons is approximately 6% to saturation. In Mortandad Canyon, a wet canyon due to effluent discharges, the moisture content in the Otowi Member is about 20% at Well R-15. Moisture content in the underlying Cerros del Rio Basalt ranges from 0.5 to 14.6% (LANL, 2000a). Additional information on Los Alamos groundwater and vadose zone characteristics will be published in groundwater annual status reports, drill hole or characterization well completion reports, and other technical reports.

Isotope and age-dating measurements have been made in an effort to better understand the nature of recharge to the regional aquifer. Samples from test wells and water-supply wells that penetrate the regional aquifer were analyzed for carbon-14 and low-level tritium to allow tentative estimates of the age of the water in the regional aquifer at various locations. The interpretation of the carbon-14 data indicates that the minimum age of water in the regional aquifer varies. Under the western portion of the plateau, the minimum age is about 1,000 years. As the water moves eastward, the age increases. Near the Rio Grande, the age of water is about 30,000 years (Rogers et al., 1996). It is important to recognize that, because the samples were collected from water drawn from screened intervals of 600 to 3,100 ft, these ages are composite water ages. Nonetheless, these ages are consistent with easterly flow, with younger water recharging at the plateau's western boundary and flowing towards the east.

Groundwater samples from the regional aquifer near Los Alamos appear to show the presence of some recent (within the last 40 years) recharge. Samples from five locations detected tritium in several measurements by extremely low-detection-limit analytical methods (Environmental Protection Group, 1995, 1994). These locations include TW-1 in Pueblo Canyon near the confluence with Los Alamos Canyon, TW-3 in Los Alamos Canyon, old observation and water-supply wells LA-1A and LA-2 in Los Alamos Canyon near its confluence with the Rio Grande, TW-8 in Mortandad Canyon, and in wells and springs at San Ildefonso Pueblo (Environmental Protection Group, 1995; Blake et al., 1995). The tritium levels measured range from less than a percent to less than a hundredth of a percent of current drinking water standards. In addition, these levels are less than the levels that could be detected by EPA-specified analytical methods normally used to determine compliance with drinking water regulations. Additionally, samples from water-supply well Otowi-1 collected during 2000 detected perchlorate (see Section A.5.3.2) that documents recent recharge to the regional aquifer.

The regional hydraulic gradient is generally to the east, with a slight southerly component in some areas. As shown in Table A-2, the gradient is fairly steep in the western portion of the plateau within the Puye Formation, less steep in the central portions, then steepening again to the east as the groundwater approaches the Rio Grande. Locally, gradients may depart from these larger scale estimates; uncertainty due to local variations at scales less than R-well spacing is probably larger than uncertainty due to measurement error. Permeability data (provided in Table A-3) show that considerable variation in permeability is present in the aquifer. Assuming average aquifer properties measured in wells in the central portion of the plateau, LANL estimates a typical groundwater velocity to be 33 meters per year [m/yr] (see Table A-4). This is in good agreement with previous estimates (Purtymun, 1995). Any such estimate has inherent uncertainties due to the difficulty in estimating the effective porosity of the medium. By choosing a value on the low end of the range typically assumed for sedimentary rocks, it is thought that the groundwater velocity estimate is a maximum bound.

A.5.3.2 Regional Aquifer Groundwater Quality

Continued testing of water-supply wells, test wells, and springs in 2001 confirm the overall quality of the regional aquifer (LANL, 2002). Trace levels of tritium are present in the regional aquifer in a few areas where past liquid waste discharges occurred, notably beneath Los Alamos, Pueblo, and Mortandad canyons. The highest tritium level found in a regional aquifer test well (Test Well-1), near water-supply well Otowi-1, was about 1/50 of the drinking water standard of 20,000 pCi/L (LANL, 2002). Tritium continued to be found in water-supply well Otowi-1, located in Pueblo Canyon, in 2001 at a level that is 1/500 the drinking water standard. Except for above-background tritium in water-supply well Otowi-1, no other radionuclides other than naturally-occurring uranium were found in Los Alamos County, San Ildefonso Pueblo, or Santa Fe water-supply wells (LANL, 2002). Nitrate concentration in Test Well-1 remained elevated; however, in 2001, the concentration was only about half the drinking water standard of 10 mg/L, and nitrate was higher than background in water-supply well Otowi 1 (LANL, 2002).

The EPA named perchlorate as a contaminant of concern after studies linked the chemical to thyroid disorders and other potential health problems. Perchlorate is a non-radioactive chemical compound used in a variety of industrial processes. At LANL, perchlorate is a byproduct of the perchloric acid used in nuclear chemistry research. Low-level concentrations (2 to 3 ppb) of perchlorate were detected in late June 2000 in water samples collected from the Otowi-1 water-supply well located in lower Pueblo Canyon (LANL, 2000b). Independent analytical laboratories corroborated LANL's analytical results, and in four separate samples collected between June 21, 2000, and July 6, 2000, perchlorate concentrations in the Otowi-1 well ranged from 2 to 3.5 ppb. In 2001, perchlorate was detected in samples collected from the Otowi-1 well at concentrations of 1.7 and 5.85 µg/L (ppb); these concentrations were dependant on analytical method (LANL, 2002). Ion chromatography (IC) and liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) were used to analyze samples collected from Otowi-1. These two methods have different detection limits; the LC/MS/MS method has a lower detection limit than the IC method.

EPA has not yet established a drinking water standard for perchlorate, but has recommended safe drinking water levels ranging from 4 to 18 ppb. The State of California, in response to EPA studies, lowered its perchlorate standard from 18 to 4 ppb. An action level or regulatory standards have not been established by the State of New Mexico. In 1998, the EPA added perchlorate to the Safe Drinking Water Act's Contaminant Candidate List for consideration for possible regulation; however, a finalized toxicity assessment and technical guidance development must be completed before a federal drinking water regulation for perchlorate would be promulgated.

LANL began testing for perchlorate in December 1997 after the California Department of Health Services identified perchlorate as a contaminant of concern. A possible source for the contamination could be legacy waste that was discharged into Acid Canyon from LANL's TA-45 treatment plant, which operated from 1943 to 1964. The plant was decommissioned in 1966 and 1967. Prior to the June 2000 detection, perchlorate had not been detected in any water-supply wells. Since 1997, LANL has submitted samples to external laboratories that utilize the most current industry-recognized minimum detection limits for perchlorate. Since 1999, LANL has sampled and analyzed (internally) four drinking water wells and several shallow and intermediate groundwater monitoring wells using the minimum detection limit of 4 ppb. Historical industry detection limits prior to 1997 were 100 ppb.

LANL personnel have successfully demonstrated the effectiveness of a new ion-exchange system installed in March 2002 at the TA-50 RLWTF, which discharges treated effluent to Mortandad Canyon. Since the installation of this special ion-exchange resin system, perchlorate concentrations in the discharged effluent have been reduced to below the EPA's approved testing method detection limit of 4 ppb. Between January 2000 and April 2001, before the new ion-exchange system was installed, monthly composite samples of effluent discharged from the RLWTF showed concentrations that ranged between 3 and 950 ppb. The modifications to the treatment operations have significantly decreased perchlorate concentrations in water discharged from the treatment facility.

Regulated units (i.e., surface impoundments, waste piles, land treatment units, and landfills, as provided by 20.4.1 NMAC § 264.90(a)(2) [6-14-00]) will meet the requirements specified in 20.4.1 NMAC §§ 260.90-100 [6-14-00], as appropriate. Currently, the regulated units at LANL include the Area G landfills (Pit 29 and Shaft 124), the Area H landfill (Shaft 9), and the Area L landfill (Shafts 1, 13-17, and 19-34 and Impoundments B and D). Areas G, H, and L are located at TA-54. Interim status groundwater monitoring data for the regulated units at LANL were not obtained as part of a groundwater monitoring program, as required by 20.4.1 NMAC §270.14(c)(1), because LANL had submitted groundwater monitoring waiver demonstrations, in accordance with 20.4.1 NMAC § 265.90(c). These waiver requests were subsequently denied, and NMED requested that LANL develop the Hydrogeologic Workplan, which would address the requirements of 20.4.1 NMAC §§ 264.91 through 264.100 for regulated units and 20.4.1 NMAC § 264.101 for solid waste management units that have been determined to have had a release. The Hydrogeologic Workplan is being used to characterize the site-wide hydrogeologic setting at the facility. The data collected will help in the identification of the regional aquifer and any hydraulically-interconnected aquifers beneath the facility property, including groundwater flow direction and rate, and the basis for such identification, as required by 20.4.1 NMAC § 270.14(c)(2). It will also be used to establish a technical basis for siting potential future monitoring wells. The groundwater wells constructed pursuant to the Hydrogeologic Workplan may be used to monitor groundwater, and, if necessary, the well characterization and groundwater monitoring data collected will be used as inputs to determine points of compliance, as required by 20.4.1 NMAC § 264.95, as well as potential future locations of groundwater monitoring wells.

As required in 20.4.1 NMAC § 270.14(c)(3), topographic maps of the hazardous waste management areas at TA-54 are included in the LANL General Part A and in the "Los Alamos National Laboratory Technical Area 54 Permit Renewal Application," Revision 3.0 (LANL, 2003). These maps also show the property boundary (if allowed by map scale) and the locations of R wells installed at the time the maps were generated. The "point of compliance," as defined under 20.4.1 NMAC § 264.95, and the groundwater flow direction and rate will be added to these maps in General Part A revisions, as appropriate, when this information is developed and refined, respectively. There is currently no known groundwater contamination from the regulated units at TA-54; therefore, a description of any plume of contamination that has entered the groundwater, as required by 20.4.1 NMAC § 270.14(c)(4), is not provided herein. LANL is currently developing a facility-wide groundwater monitoring plan which will, among other topics, discuss relevant and appropriate groundwater monitoring provisions for LANL's regulated units and solid waste management units, as required by 20.4.1 NMAC § 270.14(c)(5) through (8).

A.5.4 Groundwater Characterization

To date, numerous characterization wells have been drilled, as required by the Hydrogeologic Workplan (LANL, 1998). The installed wells include Wells R-5, R-7, R-8, R-9, and R-9i (Los Alamos/Pueblo Canyon), R-12 (Sandia Canyon), R-13 and R-15 (Mortandad Canyon), R- 14 (Ten Site Canyon), R-16 (Overlook Park in White Rock), R-19 (mesa top above Threemile and Potrillo canyons), R-21 and R-22 (on Mesita del Buey between Pajarito Canyon and Cañada del Buey), R-20, R-23, and R-32 (Pajarito Canyon), R-25 (south rim of Cañon de Valle), and R-31 (Ancho Canyon). The following provides brief descriptions of each of the characterization wells. Additional information will continue to be provided to the NMED Hazardous Waste Bureau via well summary reports, well completion reports, monitoring reports, and other technical reports.

- Well R-5 is located in lower Pueblo Canyon between the Los Alamos County Sewage Treatment Plant and water-supply well Otowi-1. Drilling activities started in April 2001, and well installation was completed in May 2001. The total depth of Well R-5 is 902 ft. The regional aquifer was reached at a depth of 685 ft. The well was completed with four screened intervals at depths of 326-331 ft, 373-389 ft, 677-720 ft, and 859-864 ft. Based on the analytical results from screening samples collected from the borehole during drilling, it appears that contamination from Laboratory discharges is not present in the regional aquifer at this well site. Additional information for Well R-5 is presented in the "Characterization Well R-5 Completion Report" (Risk Reduction and Environmental Stewardship Division [RRES] Groundwater Protection Program [GPP], 2003a).

- Well R-7 is located in upper Los Alamos Canyon. Drilling activities began in February 2000, and well construction and development were completed in February 2001. The well was drilled to a total depth of 1,097 ft. The regional aquifer was reached at a depth of 903 ft. The R-7 well was completed with three screened intervals: two associated with perched saturation at depths of 363-379 ft and 730-746 ft; and one straddling the regional water table at 895-937 ft. No contaminants above background were detected in samples collected from the borehole during drilling. Additional information for Well R-7 is published in the "Characterization Well R-7 Completion Report" (Stone et al., 2002).

- Well R-8 is located in Los Alamos Canyon, downstream of the confluence with DP Canyon. Drilling activities began in September 2001, and well construction and development were completed in February 2002. The R-8 well was drilled to a total depth of 1,022 ft. The regional aquifer was reached at a depth of 709 ft. The well was completed with two screened intervals at depths of 705-756 ft and 821-828 ft. Based on the analytical results from screening samples collected from the borehole during drilling, tritium is present at a slightly elevated level above background. Additional information for Well R-8 is presented in the "Characterization Well R-8 Completion Report" (RRES GPP, 2003b).

- Well R-9 is located in Los Alamos Canyon at the eastern boundary of LANL. During the drilling of the well to a total depth of 771 ft, five perched water zones were encountered. The regional aquifer was reached at a depth of 688 ft. Tritium levels were highest (347 pCi/L) in the uppermost perched zone and lowest (14 pCi/L) in the regional aquifer. These levels are far below the levels of health concern (20,000 pCi/L), but do indicate the movement of some water from the land surface to the groundwater zones within the past 40 or so years. Additional information for Well R-9 is published in the "Characterization Well R-9 Completion Report" (Broxton et al., 2001a).

- Well R-9i was completed in March 2000 near the eastern LANL boundary in Los Alamos Canyon to a depth of 322 ft with two screened intervals in the upper saturated zones identified in Well R-9. Additional information for Well R-9i is published in the "Characterization Well R-9i Completion Report" (Broxton et al., 2001b).

- Well R-12 is located in Sandia Canyon at the eastern boundary of LANL. This well was drilled to a total depth of 886 ft. An intermediate-depth perched groundwater zone was encountered at a depth of 424 ft, and the regional aquifer was reached at a depth of 805 ft. The perched groundwater at the 424-ft depth was found to contain nitrate, ammonia, chloride, and tritium (208.1 pCi/L). The presence of some recent recharge water is indicated at this regional aquifer location by tritium levels of 46.9 pCi/L; nitrogen isotopes present indicate a sewage influence.

Additional information for Well R-12 is published in the "Characterization Well R-12 Completion Report" (Broxton et al., 2001c).

- Well R-13 is located in Mortandad Canyon. Drilling activities began in August 2001, and well construction, development, and site completion were finished in February 2002. The borehole was drilled to a total depth of 1,133 ft, and the well was installed to a total depth of 1,029.4 ft. No perched water was encountered; the regional aquifer was reached at a depth of 834 ft. The well was completed with one screened interval in the regional aquifer at a depth of 958-1,019 ft. Based on the analytical results from water samples collected from the borehole during drilling, it appears that contamination from Laboratory discharges is not present in the regional aquifer at this well site. Additional information is presented in the “Characterization Well R-13 Completion Report” (RRES GPP, 2003c).

- Well R-14 is located in Ten Site Canyon, east of the former radioactive liquid waste treatment and septic facilities at TA-35. Preparation and drilling activities began in May 2002, and well construction, development, and site completion were finished in February 2003. The well was drilled to a total depth of 1,327 ft. No perched water zones were encountered; the regional aquifer was reached at a depth of 1,182 ft. The well was completed with two screened intervals in the regional aquifer at depths of 1,201-1,233 ft and 1,286-1,293 ft. Two water samples were collected from the screened intervals in the regional aquifer during well development activities. Based on the analytical results for these samples, it appears that contamination from Laboratory discharges is not present in the regional aquifer at this well site. Additional information is presented in the “Characterization Well R-14 Completion Report” (RRES GPP, 2003d).

- Well R-15 is located in Mortandad Canyon about 1.5 miles east of the RLWTF at TA-50. Both hollow stem auger and air rotary/casing advance methods were used in drilling this well. A definable intermediate perched zone was encountered at a depth of 646 ft, and the regional aquifer was reached at a depth of 964 ft. The total depth of Well R-15 is 1,107 ft. The deep perched zone contained tritium at concentrations of 3,770 ± 850 pCi/L; these levels indicate infiltration of Laboratory-derived contaminants at this location, but the levels are well below federal drinking water standards. The tritium concentration in the regional aquifer at Well R-15 is less than detection. A perchlorate concentration of 12 ppb was detected in the perched water zone at Well R-15 in December 1999 (LANL, 2000c). Additional information for Well R-15 is published in the "Characterization Well R-15 Completion Report" (Longmire et al., 2001a).

- Well R-16 is located just south of Cañada del Buey near Overlook Park in White Rock, and immediately upstream from the sanitary sewage treatment plant. Preparation and drilling activities began in July 2002, and well construction and development were completed in December 2002. The well was drilled to a total depth of 1,287 ft, and the zone of regional groundwater saturation was encountered at a depth of 642 ft. The well was completed with four screened intervals at depths of 641-649 ft, 863-871 ft, 1,015-1,022 ft, and 1,237-1,245 ft. Three water samples were collected after well development, one each from the lower three screened intervals. Based on analytical results for these three samples, contamination from Laboratory discharges does not appear to be present in the regional aquifer at this well site. Additional information is presented in the "Characterization Well R-16 Completion Report (RRES GPP, 2003e).

- Well R-19 was completed near TA-36 on the mesa above Threemile and Potrillo canyons to a depth of 1,902 ft with seven screens: two in the perched zone; and five in the regional aquifer. Additional information for Well R-19 is published in the "Characterization Well R-19 Completion Report" (Broxton et al., 2001d).

- Well R-20 is located in Pajarito Canyon, just east of TA-18 on the south side of Pajarito Road. Preparation and drilling activities began in July 2002, and well construction, development, and site completion activities were finished in March 2003. The borehole was drilled to a total depth of 1,365 ft. No perched zones were encountered during drilling, and the regional aquifer was reached at a depth of 873 ft. The well was completed with three screened intervals in the regional aquifer at depths of 905-912 ft, 1,147-1,155 ft, and 1,329-1,336 ft. Two regional aquifer water samples were collected from the developed well. Although strontium-90 was detected near the minimum detection activity level, the absence of tritium suggests that the waters have not been impacted by Laboratory releases. Additional information is presented in the "Characterization Well R-20 Completion Report" (RRES GPP, 2003f).

- Well R-21 is located in Cañada del Buey north of TA-54. This well was installed between October 2002 and February 2003. It was advanced to a depth of 995 ft. No perched water zones were encountered during borehole advancement, and the static water level of the regional aquifer was determined to be at a depth of approximately 804 ft. Based on the analytical results for screening samples collected from the single well screen, which extends from 889 ft to 907 ft below ground surface, potential contaminants of concern were not detected. Additional information for this well is published in the "Characterization Well R-21 Completion Report" (Kleinfelder, Inc., 2003).

- Well R-22 was drilled on Mesita del Buey east of TA-54, Area G, to a depth of 1,489 ft. Drilling activities began in August 2000, and well construction and development were completed in November 2000. The regional aquifer was reached at a depth of 883 ft; no perched intermediate groundwater was encountered in Well R-22. The well was completed with five screened intervals in the regional zone of saturation at depths of 872-914 ft, 947-989 ft, 1,272-1,279 ft, 1,378-1,385 ft, and 1,447-1,452 ft. Samples collected from the borehole during drilling contained tritium at concentrations above background. Additional information for Well R-22 is published in the "Characterization Well R-22 Completion Report" (Ball et al., 2002).

- Well R-23 is located in Pajarito Canyon, just west of the intersection of State Road 4 and Pajarito Road and on the south side of Pajarito Road. Preparation and drilling activities began in July 2002, and well construction, development, and site completion activities were finished in March 2003. The borehole was drilled to a total depth of 935 ft. A possible perched zone was encountered at a depth of 470 ft, and the regional aquifer was reached at a depth of 829 ft. The well was completed with one screened interval in the regional aquifer at a depth of 816-873 ft. Based on the analytical screening results of the regional groundwater samples collected, contamination from Laboratory discharges does not appear to be present in the regional aquifer at this well site. Additional information is presented in the "Characterization Well R-23 Completion Report" (RRES GPP, 2003g).

- Well R-25 is located on a mesa top at TA-16 along the south rim of Cañon de Valle near the western boundary of LANL. The total depth of Well R-25 is 1,942 ft, and the regional aquifer was reached at a depth of 1,286 ft. Well R-25 was completed with nine screened intervals: three in the upper zone of saturation; one in the intervening alternating wet/dry zone; and five in the regional zone of saturation. Contaminants detected in borehole samples included HE compounds and their associated degradation products. Subsequently, quarterly sampling has detected solvent compounds. Additional information for Well R-25 is published in the "Characterization Well R-25 Completion Report" (Broxton et al., 2002b).

- Well R-31 is located at TA-39 in the north fork of Ancho Canyon near the southern boundary of LANL. This well was drilled to a total depth of 1,103 ft. The regional zone of saturation was encountered between 521 and 537 ft; no intermediate perched zones were encountered in this well. Additional information for Well R-31 is published in the "Characterization Well R-31 Completion Report" (Vaniman et al., 2002).

- Well R-32 is located in Pajarito Canyon, within TA-36 and south of TA-54, on the north side of Pajarito Road. Preparation and drilling activities began in July 2002, and well construction, development, and site completion activities were finished in March 2003. This well was drilled to a total depth of 1,008 ft. Perched groundwater was encountered in the alluvium at a depth of 22 ft. No other perched zones were identified. The regional aquifer was reached at a composite depth of 783 ft. The well was completed with three screened intervals in the regional aquifer at depths of 867-875 ft, 932-935 ft, and 973-981 ft. Based on analytical results for water samples collected at each screened interval, contamination from Laboratory discharges does not appear to be present in the regional aquifer at this well site. Additional information is presented in the “Characterization Well R-32 Completion Report” (RRES GPP, 2003h).

The following provides brief descriptions of wells that were installed for further investigation of contaminants in groundwater:

- CdV-R-15-3 was completed at TA-15 on the mesa above Cañon de Valle in June 2000 with six screened intervals: three in the upper perched zone and three in the regional zone of saturation. The three perched zone screens are dry. Additional information for Well CdV-R-15-3 is published in the "Well CdV-R-15-3 Completion Report" (Kopp et al., 2002).

- MCOBT-4.4 in Mortandad Canyon was drilled to a total depth of 767 ft in June 2001. The borehole was plugged up to a depth of 725 ft and a single completion well was installed.

- MCOBT-8.5 in Mortandad Canyon was drilled to a total depth of 740 ft in June 2001. The borehole was plugged up to a depth of 670 ft in order to install a well in Cerros del Rio basalt. However, after several days of monitoring, the borehole did not yield water and MCOBT-8.5 was plugged back to the surface.

A.6 OTHER PERMIT ACTIVITIES

Other types of Resource Conservation and Recovery Act permits will be addressed in TA-specific permit applications, permit modification requests, or permit renewal applications.

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Table A-1
Occurrences of Intermediate-Depth Perched Groundwater

Well	Perched Water Level Depth (ft)	Unit Containing Perched Saturation	Data Source
Pueblo Canyon			
TW-2A	120	Puye Formation	Purtymun, 1995
O-1	183	Puye Formation	Purtymun, 1995
TW-1A	180	Cerros del Rio Basalt	Purtymun, 1995
R-5	375	Cerros del Rio Basalt	Longmire, 2001b
Los Alamos Canyon			
H-19	(20-ft interval)	Guaje Pumice Bed	LANL, 1995
R-7	378	Guaje Pumice Bed/Puye Formation	Longmire, 2001b
LAO(A)	295	Guaje Pumice Bed	LANL, 1995
LADP-3	325	Guaje Pumice Bed	LANL, 1995
O-4	253	Puye Formation	Purtymun, 1995
R-9	137	Cerros del Rio Basalt	Broxton et al., 2000
R-9	264	Cerros del Rio Basalt	Broxton et al., 2000
R-9	524	Cerros del Rio Basalt	Broxton et al., 2000
Sandia Canyon			
R-12	424	Cerros del Rio Basalt	Broxton et al., 2000
PM-1	450	Cerros del Rio Basalt	Purtymun, 1995
Mortandad Canyon			
MCM-51	55	Tsankawi/Cerro Toledo	LANL, 1997
MCM-5.9	105	Tsankawi/Cerro Toledo	LANL, 1997
R-15	646	Cerros del Rio Basalt	Longmire et al., 2000
Pajarito Canyon			
SHB-4	145	Cerro Toledo interval	LANL, 1998
R-19	909	Puye Formation	Longmire, 2001b
54-1016	592	Cerros del Rio basalt	LANL, 1998
Cañon de Valle			
R-25	747	Otowi Member	Nylander et al., 2001
Ancho Canyon			
R-31	440	Cerros del Rio basalt	Marin, 2000

Table A-2

Estimated West-East Hydraulic Gradients

Pair of Wells				West-East Distance (m)	Gradient (m/m)
Upgradient Well	Water level (m)	Downgradient Well	Water level (m)		
R25	1836	CDV15-3	1833	2189	-0.02884
CDV15-3	1833	R19	1795	4710	-0.02149
DT-10	1805	R22	1747	5195	-0.01121
R15	1785	R12	1738	3684	-0.01283

Table A-3

Permeability Data for Rocks in the Regional Aquifer

Stratigraphic Unit	Well	Permeability (log m^2)	Hydraulic Conductivity (ft/day)	Hydraulic Conductivity (m/yr)
Tsf	O-1	-12.64	0.63	70.11
	LA-6	-12.36	1.22	135.76
	LA-5	-12.84	0.4	44.51
	LA-4	-12.56	0.44	48.96
	LA-3	-12.8	0.44	48.96
	LA-2	-12.77	0.47	52.30
	LA-1B	-12.35	1.25	139.10
	G-4	-12.26	1.51	168.03
	G-3	-12.59	0.71	79.01
	G-2	-12.36	1.22	135.76
	G-1A	-12.36	1.22	135.76
	G-1	-12.47	0.94	104.60
Tsfuv	DT-9	-11.23	16.35	1819.44
	O-4	-11.84	4.02	447.35
	PM-4	-11.94	3.22	358.32
Tpf	TW-8	-11.92	3.35	372.79
	R-15	-12.14	2.01	223.67
	R-15	-11.92	3.32	369.45
	R-19	-11.2	17.5	1947.41
	R-19	-11.15	19.6	2181.10
	CDV-R-15	-13.05	0.25	27.82
	CDV-R-15	-13.44	0.1	11.13
	R-9[a]	-15.22	.002	0.18
	R-12[a]	-17.8	4.E-6	.0005
	R-12[a]	-15.01	.003	0.30
Tpt	TW-3	-11.24	16.08	1789.39
	TW-2	-10.93	32.39	3604.38
	TW-1	-12.71	0.54	60.09

Stratigraphic Unit	Well	Permeability (log m²)	Hydraulic Conductivity (ft/day)	Hydraulic Conductivity (m/yr)
Tb	PM-5	-12.59	0.71	79.01
	G-5	-12.38	1.17	130.20
	DT-10	-11.27	14.87	
	R-31	-12.41	1.07	119.07
	R-31	-12.82	0.42	46.74
	R-31	-11.88	3.62	402.84
	R-31	-14.49	0.01	1.11
	R-31	-14.6	0.01	1.11
	R-9i	-10.87	37.07	4125.17
	R-9i	-12.55	0.78	86.80
	R-9[a]	-14.9	.003	0.30
	R-12[a]	-18.4	1.1E-6	.00012
Tt	TW-4	-12.04	2.55	283.77
Average[b]		-12.30	1.38	153.25

[a] Derived from core measurements
[b] Excluding core measurements

Table A-4

Groundwater Velocity Estimate

Gradient (m/m)	Hydraulic Conductivity (m/yr)	Porosity	Calculated Velocity (m/yr)
.019[a]	176 m/yr[b]	0.1[c]	33

[a] Average of gradients shown in Table A-2
[b] Geometric average of data shown in Table A-3, excluding LA well field (due to its lower permeability)
[c] At low end of range typically reported for sedimentary rocks (0.1 – 0.3)